Journal of Scientific Exploration, Vol. 27, No. 1, pp. 13–23, 2013 0892-3310/13

RESEARCH ARTICLE

Longitudinal Electromagnetic Waves? The Monstein–Wesley Experiment Reconstructed

Edward J. Butterworth
Department of Physics and Geosciences, Texas A&M University–Kingsville
kuejb000@tamuk.edu

Charles B. Allison
Department of Physics and Geosciences, Texas A&M University–Kingsville

Daniel Cavazos
College of Engineering, Texas A&M University–Kingsville

Frank M. Mullen
The Department of Industrial Technology, Texas A&M University–Kingsville

Submitted 5/18/2012, Accepted 9/29/2012, Pre-published 1/15/2013

Abstract—We repeat the experiment reported in a controversial publication of Monstein and Wesley (MW), in which they claimed to have detected longitudinal electromagnetic (EM) waves in free space, a phenomenon incompatible with Maxwell's equations. While we are convinced that Maxwell's equations are valid and that longitudinal EM waves do not exist, we recognized that the radiation pattern observed in the MW experiment was itself interesting, while noting that no one had actually repeated MW's experiments. Therefore we constructed a duplicate of MW's apparatus and ran their experiments along with some additional ones. We intended both to test whether MW's results could be duplicated, and to distinguish between their theoretical model and that of a critical article published by Rębilas proposing ground plasma currents as the true cause of the waves observed by MW. We also determined the field pattern of the ball antenna experimentally. Our experimental results actually resemble MW's theoretical pattern more closely than did their own experiment, an interesting result considering that MW's theory is almost universally considered incorrect. However, our experimental results were not compatible with Rębilas' (very plausible) theoretical explanation. Thus we dispute MW's claim on theoretical grounds, and Rębilas' ground plasma currents on experimental grounds. We conclude that a yet-unidentified mechanism must be producing the observed results.

Keywords: Electromagnetic waves—Maxwell's equations—scalar waves—ball antenna—radiation pattern

Introduction and Background

We investigate a controversial publication by Monstein and Wesley (MW) (2002), in which they claimed to have detected longitudinal electromagnetic (EM) waves propagating in free space. Maxwell's equations represent the substance of classical electrodynamics: These four equations, taken together, preclude the existence of a longitudinal electric field component in a free-space wave (Bruhn 2002, Burko 2008, Kühlke 2008); thus the existence of such waves would require rewriting EM field theory. Most claims asserting the existence of such waves have been shown to rest upon obvious fallacies, poor observations, or misinterpretations of data (Meyl 2001, Bruhn 2002). MW's work has garnered attention largely due to their unique experimental design and the unusual character of their published experimental results. Articles both pro and con appeared in response to MW's, while Rębilas (2008) derived a possible alternative explanation for MW's results. None of these responders, however, built the MW apparatus and repeated the experiments.

Beginning with a sinusoidal solution to the wave equation and making some assumptions about the nature of the wave propagation, MW derive an equation for the signal intensity of the purported longitudinal EM waves as a function of distance between transmitter (Tx) and receiver (Rx):

$$S = \left(\frac{wkx}{2r_1^3 r_2^3}\right)\left[B^2 r_1^3 + A^2 r_2^3 + ABr_1 r_2 (r_1 + r_2)\cos k(r_2 - r_1) + \left(\frac{AB}{k}\right)\left(r_1^2 - r_2^2\right)\sin k(r_2 - r_1)\right] \tag{1}$$

Here A and B are wave amplitudes,

$$r_1^2 = (h_R - h_T)^2 + x^2 \text{ and } r_2^2 = (h_R + h_T)^2 + x^2$$

where h_R and h_T are the Tx and Rx heights, respectively, x is the Tx-Rx distance along the ground.

The MW experimental apparatus is described briefly as follows. Tx, powered by a 12 V battery, feeds a 433.59 MHz signal into a ball antenna (r = 30 mm). Rx consists of a similar ball antenna coupled to a field-effect transistor and voltmeter, also powered by a 12 V battery. Between Tx and Rx are positioned a pair of rotatable polarizer–analyzer arrays, intended to filter out waves polarized perpendicular to its orientation. MW claim that with both directions perpendicular to the direction of propagation thus blocked, only waves with a longitudinal electric field can pass.

Following MW's publication, a response by Bray and Britton (2004) disputed both their claims: that MW's theoretical analysis was compatible with Maxwell's equations; and that a ball antenna cannot generate a classical TEM wave. They also show that MW's prediction of the behavior of a uniform spherical charge density contradicts the continuity equation. In their response to this criticism, MW (2004) concede that their equation is not compatible with Maxwell's equations, but now assert explicitly that Maxwell's equations must be modified to admit the longitudinal waves that they claim to have detected.

Because MW's experimental results were being cited by those who have argued for the existence of free-space longitudinal waves (Van Vlaenderen 2003, 2005), Rębilas (2008) considered it important not only to document the flaws in MW's theoretical discussion, but also to explain their experimental results using classical electrodynamics. He explained the effect in terms of ground currents and plasma theory, deriving a signal strength equation of the form:

$$S(r) \propto \left[\int_0^{2\pi} \int_0^{\infty} \frac{e^{-\alpha r'} \cos\left(\beta r' + k_a \, \Delta r\right) \cos\phi}{\Delta r} \, \mathrm{d}r' \, \mathrm{d}\phi \right]^2 + \left[\int_0^{2\pi} \int_0^{\infty} \frac{e^{-\alpha r'} \sin\left(\beta r' + k_a \, \Delta r\right) \cos\phi}{\Delta r} \, \mathrm{d}r' \, \mathrm{d}\phi \right]^2 \qquad (2)$$

(we have corrected an integration order mistake in the original) where r is the vector from ground zero below Tx to the Rx ball antenna, Δr is the vector from the field point (on the ground) to the receiver, φ is the angle between the Tx-Rx vector and the Tx-field point vector, and k_a is the free-space wavenumber. He superimposed the graph obtained from this equation over MW's experimental data, to make the case that it represents that data more closely than does MW's theory.

Since no one had built a duplicate MW apparatus, we chose to do this and to conduct experiments to assess whether MW's results are reproducible, along with additional experiments that might shed more light on this effect, and also to test Rębilas' theoretical predictions. This was not a trivial task: Bray and Britton previously noted that the nature of the experiment makes it extremely difficult to control the variables against many possible forms of external interference. We reject the claim that free-space longitudinal EM waves can exist and thus that Maxwell's equations need modification; rather, we recognize that the results of the MW experiment have generated interest, and thus we have attempted to duplicate them as a step toward determining the source of the signal amplitude pattern they observed.

Methods and Materials

Following MW's description of the apparatus, we constructed the ball antennae, support stanchions, half-wave dipole antennae for comparison purposes, and a pair of polarizer–analyzers consisting of nine wires in 3 × 3 arrays, a half-wavelength long and a quarter-wave apart, one horizontal and one vertical. The horizontal polarizer can be rotated.

The ball antennae were constructed from solid 3″ diameter aluminum balls (Craig Ball Sales, Seaford, Delaware). Machining was done at the Industrial Technology machine shop at Texas A&M University. The antennae were mounted on 2 m–high stanchions (lower than MW used). The signal was transmitted at 446 MHZ (very close to MW's frequency) using a Realistic HTX-404 440 MHz Amateur UHF transceiver, and the received signal was analyzed using a Signal Hound USB-SA44B Signal Analyzer linked to a Dell Inspiron laptop computer. Power was supplied using 12 V storage tanks.

We performed a wider range of experiments than MW reported. We first tested the antennas indoors, over distances of less than 10 m, with and without the polarizer–analyzer arrays, with the ball antennas as well as half-wave dipoles in vertical and horizontal position. The transmit–receive characteristics of the ball antennae were compared with those of half-wave dipoles. We mapped the radiation pattern of the ball antenna at close range as a function of angle from the apex of the ball.

Next we conducted full-scale tests outdoors, increasing the Tx-Rx distance in 2 m increments at smaller distances, then in larger increments at greater distances. Available space limited our Tx-Rx separation to a maximum of 90 m. We also measured signal strength as a function of angle, with the Tx ball antenna fixed in location and orientation while the Rx ball antenna was moved to positions around it, always with the apex of the Rx antenna pointed toward the Tx antenna. Again this test was performed both with and without the polarizers in place. To provide an additional comparison, we set up the apparatus in an indoor corridor 30 m in length, and took readings every 2 m, both with and without the polarizers in place.

Results

We wrote a program to compute signal as a function of Tx-Rx distance from MW's signal equation (Equation 1 above), and ran it first with their input values, then again with our own input values. In this way we reproduced their graph of signal strength as a function of Tx-Rx distance over the distance of

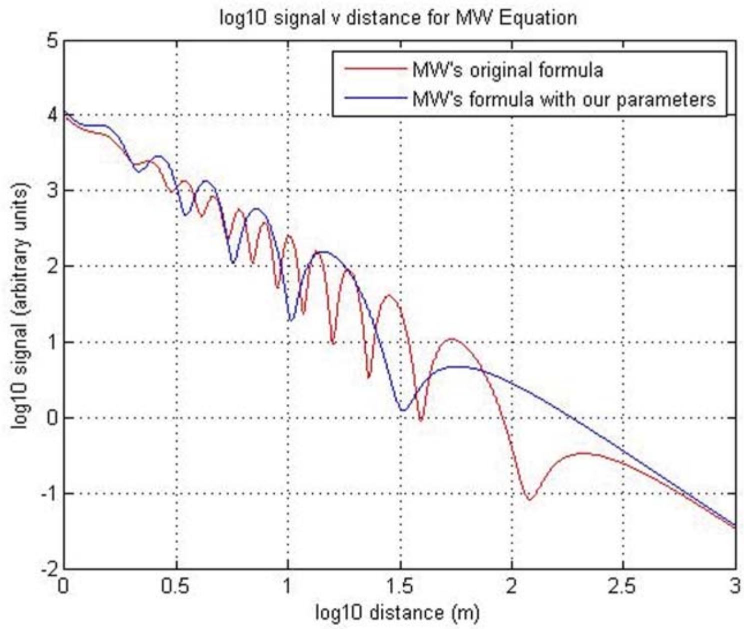

Figure 1. The graphs were generated numerically using MW's signal equation, using MW's parameters (red), and adjusted for our actual input values (blue). The only changes were a reduced height for the transmitter and receiver, and a slightly higher frequency. We extended the study down to a minimum separation of 1 m, whereas MW used 10 m.

10–1000 m, but also extended the range down to 1–10 m to reveal additional minima, shallower and closer together. With our parameters, we generated another graph that is superimposed on MW's graph in Figure 1.

We did not observe the effects MW reported for the polarizer–analyzer arrays. Rotating the array did not produce the power null at a deflection angle of 0° that they show in their Fig. 3. Indeed, the presence or absence of the polarizers had only a small effect on signal intensity as a function of distance. We conclude that they were not in fact polarizing the EM waves during the ball antenna experiments. They did, however, appear to function as polarizers when we used simple half-wave dipole antennae instead of the ball antennae. We further tested the effect of the polarizers by measuring signal intensity as a function of angle, with and without the polarizers in place, outdoors, with the zero angle representing the front face of the Tx antenna. In both cases there appears a peak intensity separated from a null by an angle of 45°. Without the polarizers, the peak intensity appeared at

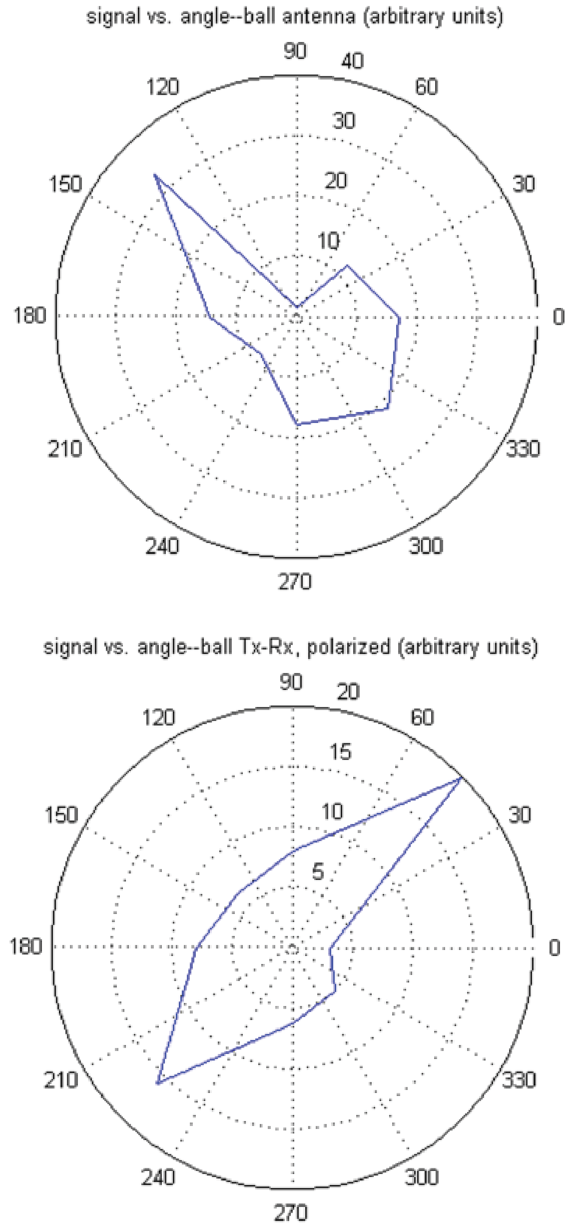

Figure 2. Polar plots of the signal strength when ball antennae are used for both transmit and receive functions, both without (above) and with (below) the polarizers in place. The angle of zero represents the frontal face of the Tx ball antenna. The main effect of the polarizers was to shift the angle at which the signal is strongest by π/2.

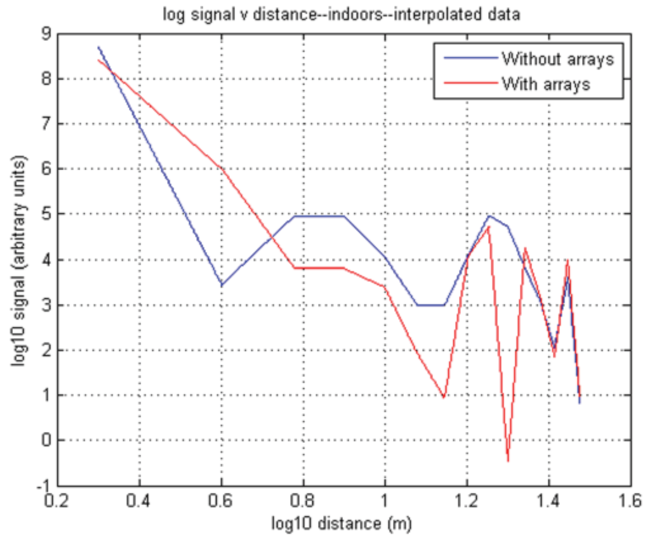

Figure 3. Results of an experiment conducted indoors, in an east–west oriented hallway of length 30 m. We present the signal intensity recorded both without the polarizer-analyzer arrays (blue), and with them in place (red). With a few exceptions, most notably the data point at a distance of 20 m, the shapes of the curves are similar.

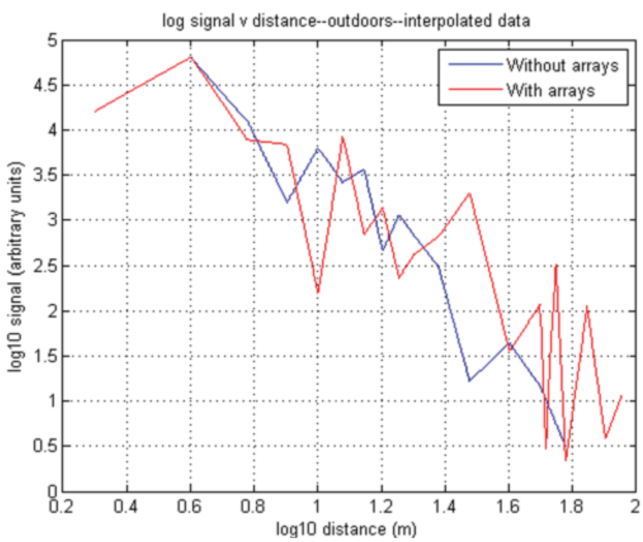

Figure 4. Data recorded outdoors with the transmitter and receiver in an east–west orientation over separations up to 90 m, again without the polarizer–analyzer arrays (blue), and with them in place (red). Some additional data points were obtained in the second case, and we believe the behavior of the signal around the 60 m separation was affected by external interference but have not been able to identify the source. Again, there is a general similarity in the shapes of the curves, with a few exceptions. A few additional data points were obtained with the arrays in place.

an angle of 135°; with them, it appears at 45°. Thus the polarizers rotate the positions of the peak intensity and the null by an angle of 90° in the clockwise direction (Figure 2).

The most interesting measured quantity is the position and depth of the signal minima as functions of transmit–receive distances. We show these in Figure 3 for the indoor study; and in Figure 4 for the outdoor study.

For the various theoretical and experimental plots, the locations of these signal minima are as follows:

MW model, their values (read from their graph, to the nearest meter, 10–1000 m): 12, 16, 23, 40, 120 m
MW model, their parameters (from our numerical representation, to the nearest tenth of a meter, 1–1000 m): 2.1, 3.0, 4.0, 5.0, 6.8, 8.9, 11.8, 15.8, 22.8, 39.4, 120.7 m (Note that the last five of these values correspond very closely to MW's, as expected.)
MW model, our parameters (from our numerical representation, 1–1000 m): 2.2, 3.6, 5.6, 10.4, 32.9 m
MW experimental values (read from their graph, 10–1000 m): 24, 30, 40 m
Rębilas' model (read from his graph, 10–1000 m): 25, 34, 43, 53, 61, 70.5, 81, 87 m
Indoor experiment, without polarizers (1–30 m): 4.0, 12.6, 26.3, 29.8 m
Indoor experiment, with polarizers (1–30 m): 5.9, 13.5, 19.5, 26.3, 29.8 m
Outdoor experiment, without polarizers (1–90 m): 7.9, 15.8, 29.5, 60.3 m
Outdoor experiment, with polarizers (1–90 m): 10.0, 17.8, 39.8, 60.3 m

Discussion

We agree with Bray and Britton that the nature of this experiment makes it impossible to control all variables, so we compensated by running experiments under a broader set of conditions than did MW: in different locations, with the antennae positioned in different orientations, outdoors and indoors, in order to identify some effects that might occur due to interference in a particular situation. Nevertheless, the present results are reported as preliminary: More complex and elaborate experiments are possible with this apparatus.

Here we compare MW's theoretical graph, their experimental data, Rębilas' theoretical graph, and our experimental data. When we modeled MW's equation, we used a minimum Tx-Rx separation of 1 m rather than 10 m, and we tested the small-separation behavior experimentally by taking measurements down to a minimum separation of 2 m. We did not observe the close (<8 m) minima predicted by MW's formula with our parameters (at least in the outdoor experiments). However, those minima are not as deep as the more distant ones in MW's simulation, and we may not have had the sensitivity to detect them.

MW's experimental data do not show their predicted minima at 12 and 16 m, nor the deep minimum predicted at 120 m or any distinct minima after 40 m, but rather a long tail-off that roughly approximates an inverse-square relation until about 200 m which then falls off more rapidly. Rębilas claims that MW's graph and their experiment are not a good match, and his graph correctly predicts MW's observed first null at 24 m. However, our observation of his graphs does not accord with his claim to have predicted the double minima at 32 and 39 m. He also predicts a series of unobserved smaller minima up to 200 m. Since Rębilas did not provide the actual parameters used in his calculation, we were unable to replicate his graph computationally and instead used his published graph.

The most pronounced difference between MW's and Rębilas' equations is that the former predicts deeper minima at increasing separations with increased Tx-Rx distance, while the latter predicts shallower minima at nearly equal separations with increased distance. It is possible that Rębilas' smaller predicted minima of about 100 m may have been under MW's detection threshold, but our experimental results suggest rather that successive minima do in fact become progressively deeper and farther apart with increasing Tx-Rx distance. This was observed indoors and outdoors, with or without polarizers in place. This result accords at least roughly with MW's predictions, but is incompatible with Rębilas' simulation, and we do not see his theory as providing a better match either to MW's data or to ours. Although his explanation is theoretically plausible, we conclude that his proposed ground plasma currents were not a major contributor to the signal that we observed.

Although our experiments show some general similarities to MW's calculations and experiments, the detailed patterns of minima are quite different. Most likely, the difference between the indoor and outdoor runs is due largely to environmental factors (possible presence of conducting materials, etc.). As explained above, the "polarizer–analyzers" did not function as such in any experiment in which the ball antennae were used for Tx and Rx: They did not null the signal in any orientation. Rather, their effect seemed comparable to the indoor–outdoor differences: They changed the shape of the response curve, and shifted the positions and depths of the minima somewhat. This result suggests that a process other than that described by MW was at work here. In both the indoor and outdoor experiments, a deep signal minimum at a distance of 19.5 m (indoors) and 39.8 m (outdoors) was observed only when the polarizers were used. We cannot explain this minimum at present.

Conclusion

Classical electrodynamics as formulated in Maxwell's equations does not admit longitudinal EM radiation propagating in free space. In agreement with Bruhn, Bray and Britton, and Burko, our reading of MW's theory suggests that it is internally flawed and that it provides no compelling rationale for questioning the foundations of classical electrodynamics. Nevertheless, MW's experiment was of a clever design, and amid speculation as to the true cause of their observed results, it befit us to build the apparatus and conduct their experiment ourselves, along with additional experiments that could further illuminate the subject. While the experiment is difficult to control and we observed evidence of environmental interference, one pattern emerged consistently: The observed signal minima become deeper and farther apart with increasing Tx-Rx distance.

Modeling MW's equation with our input data generates fewer minima, although they still follow the pattern of increasing depth and separation with increasing distance. Because we used a frequency close to MW's, we expect that the lower height of the antennae was a significant factor in this difference. Although we reject MW's theoretical explanation, we note that that their equation does predict the important common feature of minima with increasing depth and separation with increasing Tx-Rx distance. Meanwhile, the effects we observed were completely incompatible with Rębilas' simulation. While his theory of ground plasma currents contains no scientific mistakes and is certainly plausible, we must conclude that it cannot be a major contributor to the observed signal.

Because our principal purpose was to build the apparatus, perform the experiments, and compare our results to MW's theory and experiment as well as to Rębilas' explanation, we did not attempt to develop a theoretical model for the signal. Their theory, however, must still be addressed. Concerning the theory of the ball antenna, MW write that

> The spherically symmetric current density **J** within the ball, that gives rise to the pulsating surface charge, is divergenceless, $\nabla \cdot \mathbf{J} = 0$; so $\nabla \cdot \mathbf{A} = 0$ and $\nabla \times \mathbf{A} = 0$; and no transverse wave can arise.

Bray and Britton note that such a divergenceless source contradicts the continuity equation $\nabla \cdot \mathbf{J} = -\frac{\partial \rho}{\partial t}$ since it would require that the oscillating charge density be zero. Hence if $\nabla \cdot \mathbf{J} = 0$ at the source, no EM wave can arise. Since the ball antenna is clearly emitting EM radiation, we conclude that a very different process must give rise to these waves. We are working to derive a theoretical model for the field pattern of the ball antenna for future publication. It is our expectation that such a model will depend very sensitively on the point within the ball antenna at which it is actually driven.

Some methodological concerns remain as well. MW performed no statistical analysis either on the data acquisition itself or on the comparison between the acquired data and the simulations. Instead they simply "eyeballed" the results, and for the present we have done the same. While this is in part understandable due to the nature of the experiment and the difficulty involved in controlling the environment, an appropriate statistical analysis might provide additional insight into the results. We are currently looking into the possibility of developing appropriate statistical methods both for analyzing the data and for quantifying the comparison between data and theory.

We are planning to conduct more experiments with this apparatus, and we invite collaboration from others interested in this issue.

Acknowledgments

This research was supported by a grant from the College of Arts & Sciences at Texas A&M University-Kingsville.

References

Bray, J. R., & Britton, M. C. (2004). Comment on "Observation of scalar longitudinal electrodynamic waves" by C. Monstein and J. P. Wesley. *Europhysics Letters*, *66*(1), 153–154.

Bruhn, G. W. (2002). Can longitudinal electromagnetic waves exist? *Journal of Scientific Exploration*, *16*(3), 359–362.

Burko, L. M. (2008). Transversality of electromagnetic waves in the calculus-based introductory physics course. *European Journal of Physics*, *29*, 1223–1234.

Kühlke, D. (2008). "Scalar wave effects according to Tesla" and "Far range transponder" by K. Meyl. *Journal of Scientific Exploration*, *22*(2), 227–232.

Meyl, K. (2001). Scalar waves: Theory and experiments. *Journal of Scientific Exploration*, *15*(2), 199–205.

Monstein C., & Wesley, J. P. (2002). Observation of scalar longitudinal electrodynamic waves. *Europhysics Letters, 59*(4), 514–520.

Monstein, C., & Wesley, J. P. (2004). Remarks to the Comment by J. R. Bray and M. C. Britton on "Observation of scalar longitudinal electrodynamic waves." *Europhysics Letters*, *66*(1), 155–156.

Rębilas, K. (2008). On the origin of "longitudinal electrodynamic waves." *Europhysics Letters*, *83*(6), 60007.

Van Vlaenderen, K. (2003). http://www.zpenergy.com/modules.php?name=News&file=article&sid=465

Van Vlaenderen, K. (2005). http://freenrg.info/Physics/Scalar_Vector_Pot_And_Rick_Andersen/Scalar_Maths.htm